

Climate change and Hawaii's coral reefs

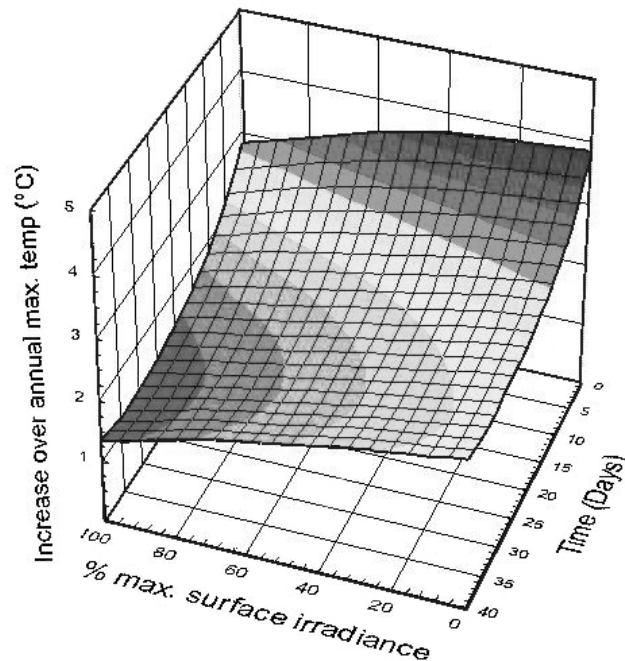


Agencies involved in research & management of Hawaii's coral reef resources

**Hawaii Division of Aquatic Resources
NWHI Coral Reef Ecosystem Reserve
National Marine Fisheries Service
Fish and Wildlife Service
US Geological Survey
University of Hawaii
Bishop Museum**

Introduction

- The bleaching response of corals in Hawaiian waters is complex but highly predictable.
- The bleaching threshold in corals is controlled primarily by temperature, irradiance and duration of exposure. This pattern is further modified by water motion, sedimentation and other factors as described by Jokiel (in press).

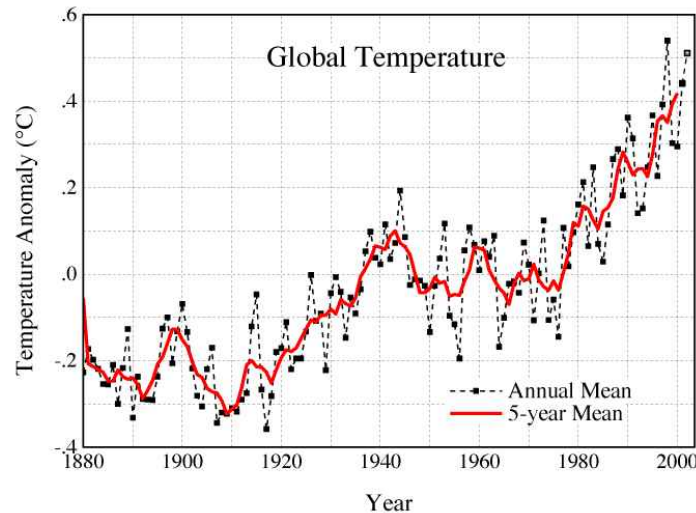


The tolerance ceiling for corals is governed by temperature elevation above mean annual summer maximum, per cent of peak annual surface solar irradiance and duration of exposure. Corals living at conditions below the tolerance ceiling will not show adverse effects. Bleaching and death result from conditions above this ceiling.



Source: P. L. Jokiel (in press) "Temperature stress and coral bleaching".
Hawaii Coral Reef Assessment and Monitoring Program (CRAMP)

Global warming?



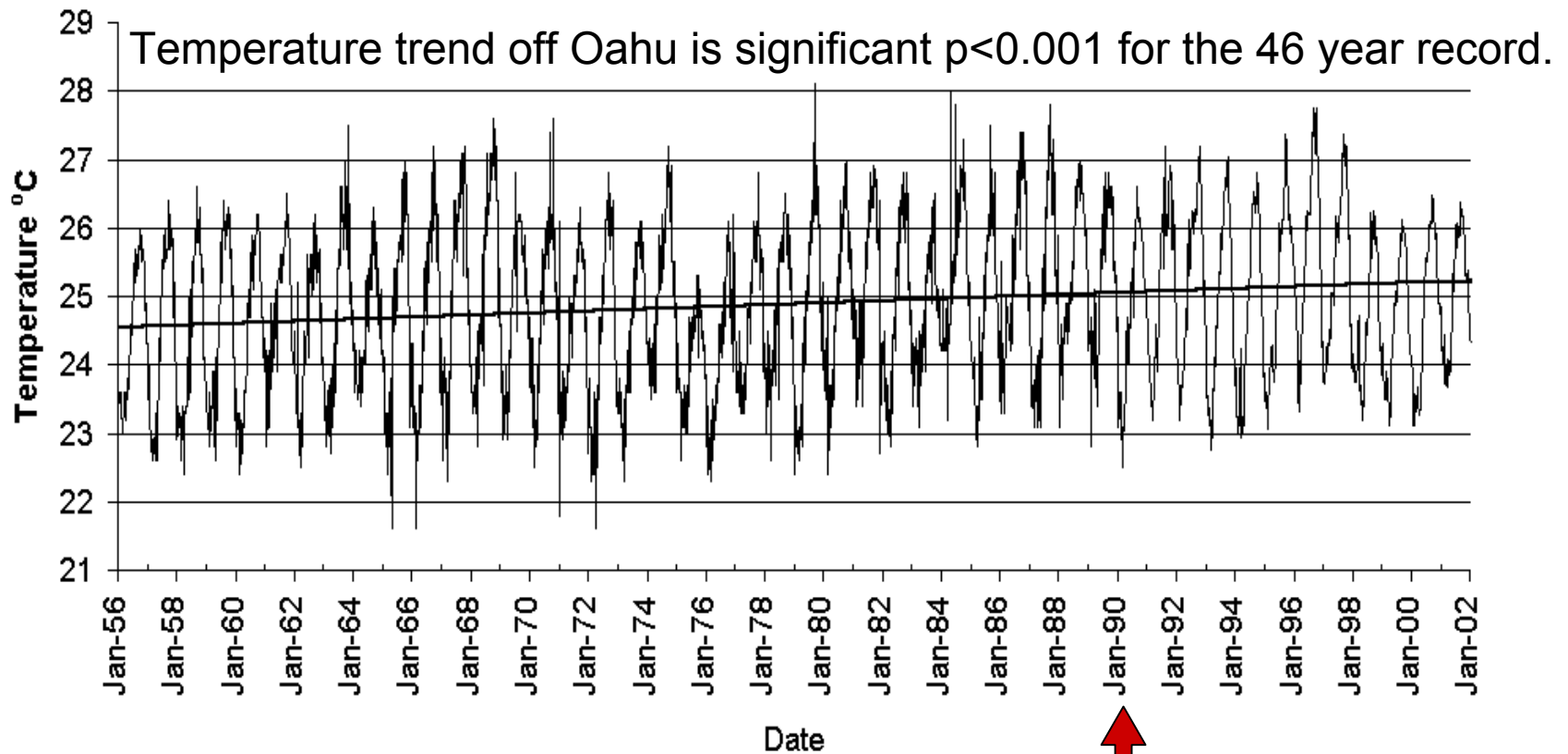
Data Source: NASA Goddard Institute

Results of extensive research on thermal tolerance of Hawaiian corals conducted in the 1970s and identification of a warming trend in Hawaiian waters led Jokiel and Coles (1990) to predict that mass bleaching would soon occur in the Hawaiian Archipelago if the trend continued.



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Koko Head NMFS (1956-1992) plus corrected IGOSS-NMC (1992-2002)



Jokiel and Coles (1990) predict major bleaching

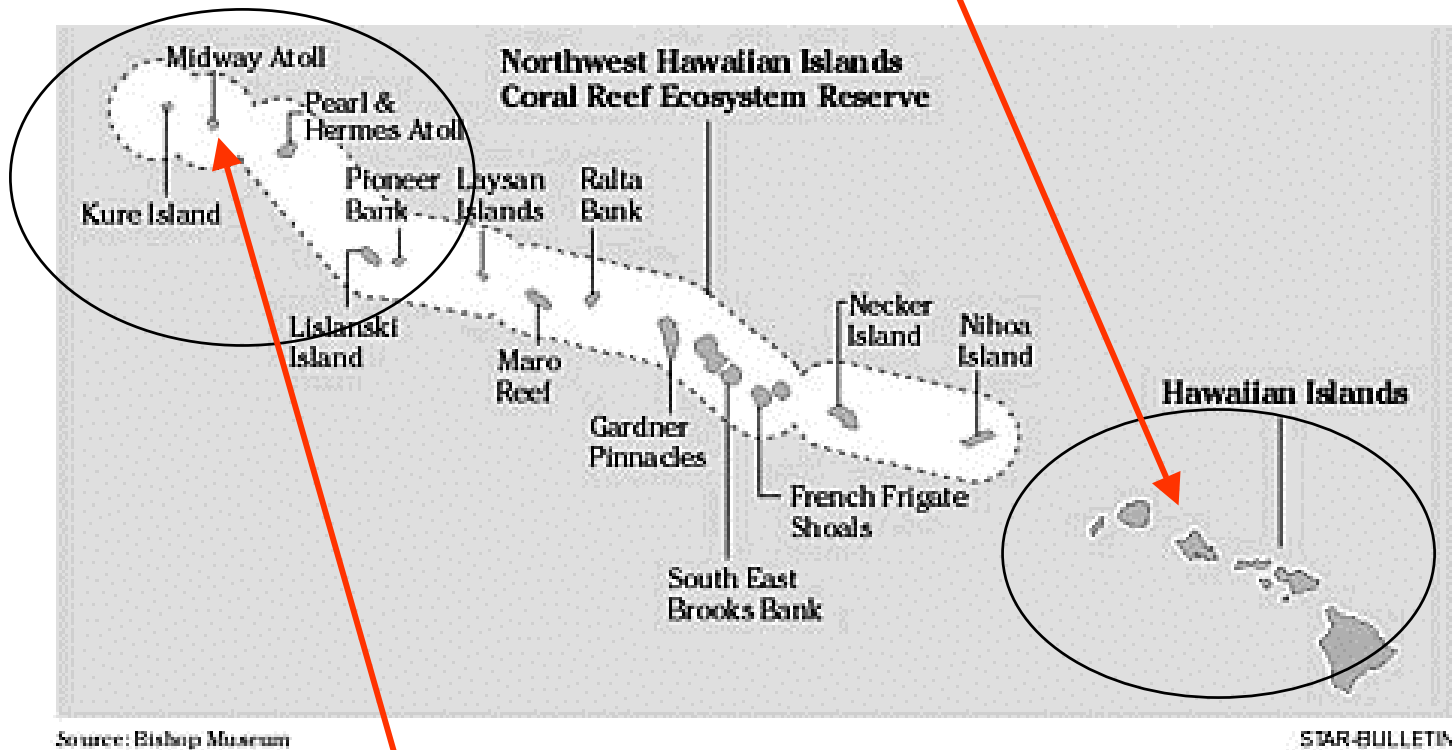
First major bleaching (Main Hawaiian Islands)

Major bleaching event, Northern Hawaiian Archipelago



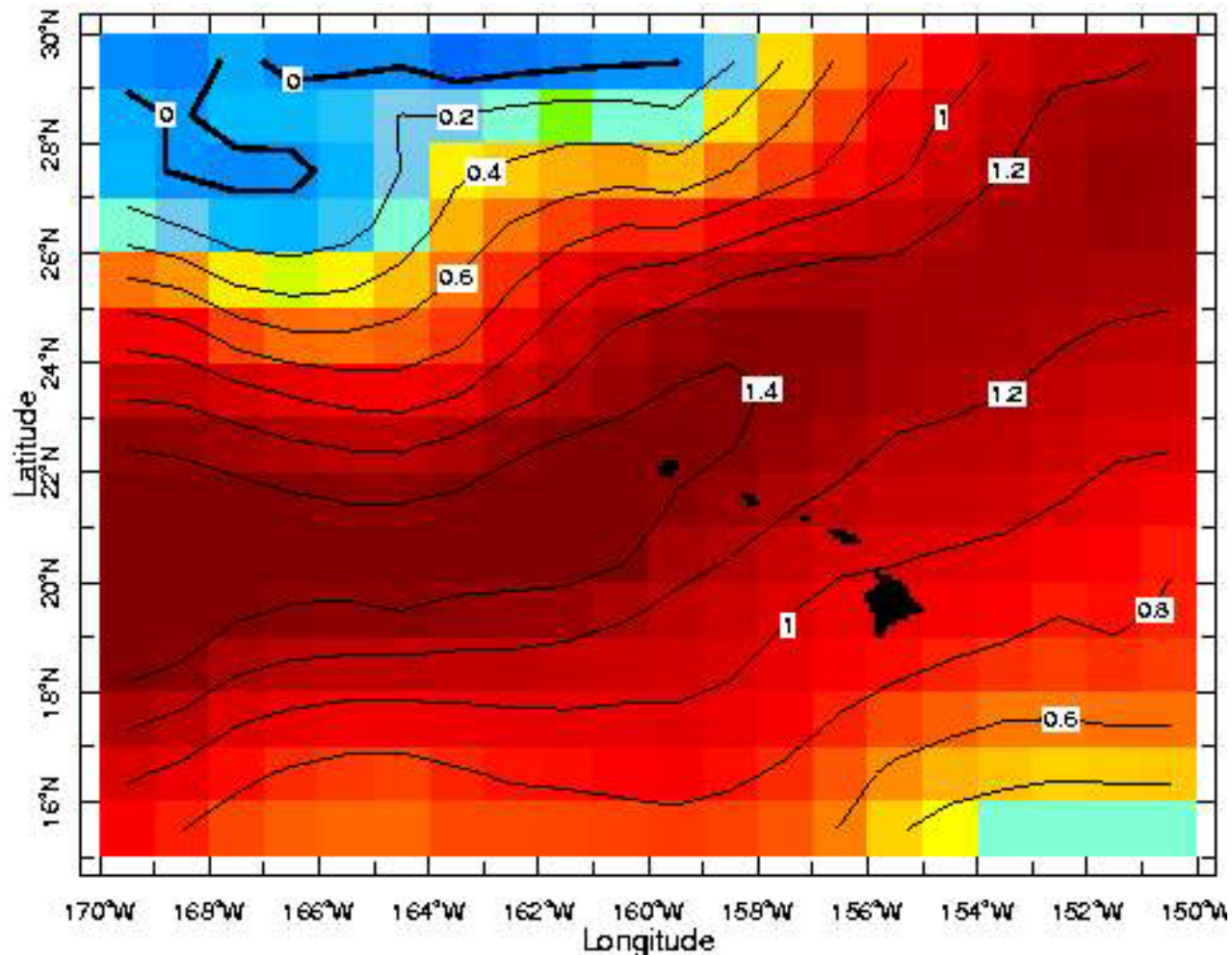
Source: P. L. Jokiel and E. K. Brown "Coral bleaching in relation to regional temperature trends and patterns". Hawaii Coral Reef Assessment and Monitoring Program (CRAMP)

The first mass bleaching occurred in 1996 in the main Hawaiian Islands.



A second major bleaching event occurred in 2002 centered in the northern portion of the Archipelago





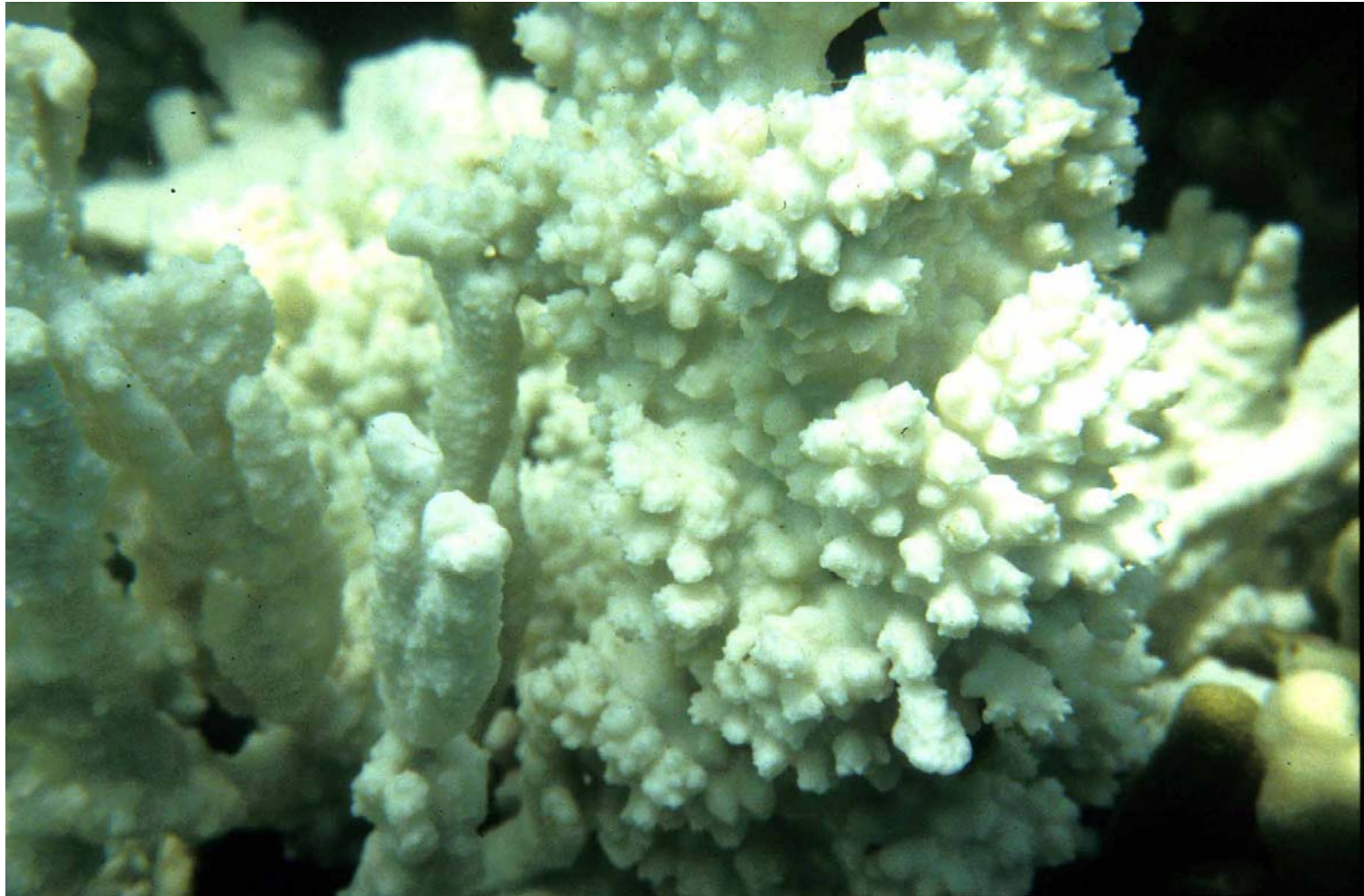
9 Oct 1996 Temperature values are in °C above mean long term summer maximum.

The 1996 bleaching event impacted the Main Hawaiian Islands with cooler temperatures in the northern portion of the Archipelago.

Data Source: Integrated Global Ocean Services Division (IGOSS), US National Meteorological Center (NMC)



The 1996 bleaching event impacted corals at Johnston Atoll (Cohen et al. 1997) and in the Main Hawaiian Islands. Impact in the Main Hawaiian Islands was greatest in Kailua Bay and Kaneohe Bay, Oahu. Less severe bleaching was reported from leeward Maui and leeward Hawaii.



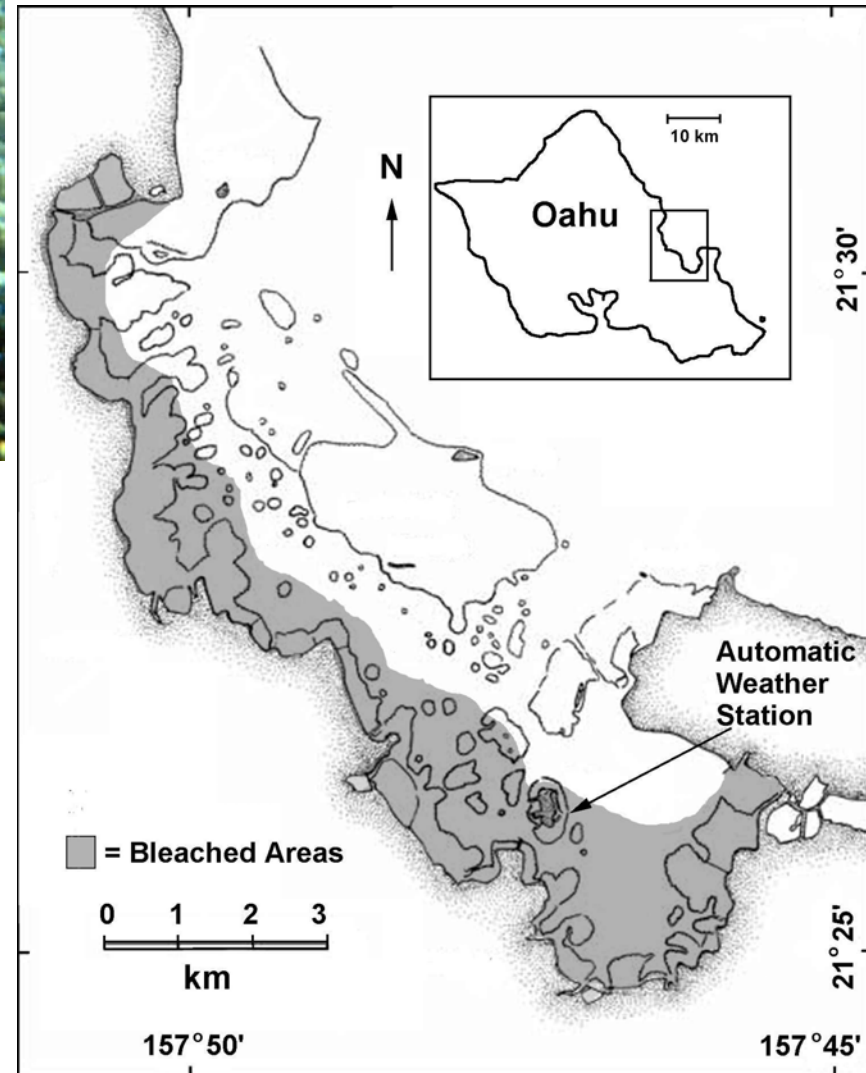
Hawaii Coral Reef Assessment and Monitoring Program (CRAMP)
Bleached *Montipora*, Kaneohe Bay, Sept. 1996. Photo by P. L. Jokiel



Bleached *Porites compressa*, Kaneohe Bay, Sept. 1996

Monitoring of meteorological parameters and water temperature conducted in Kaneohe Bay illustrate the major factors involved in a mass bleaching event.

Kaneohe Bay, Oahu, 1996 Bleaching Event

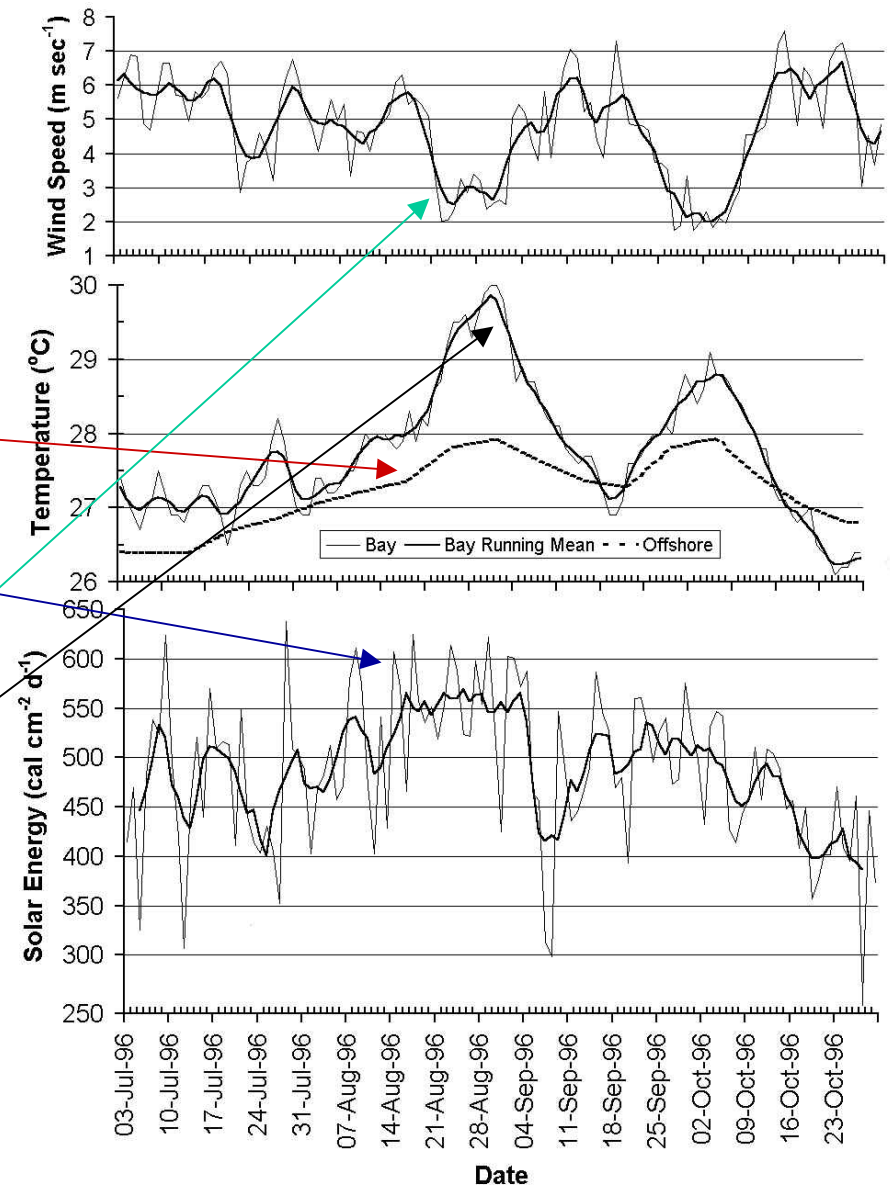


Source: P. L. Jokiel and E. K. Brown "Coral bleaching in relation to regional temperature trends and patterns".
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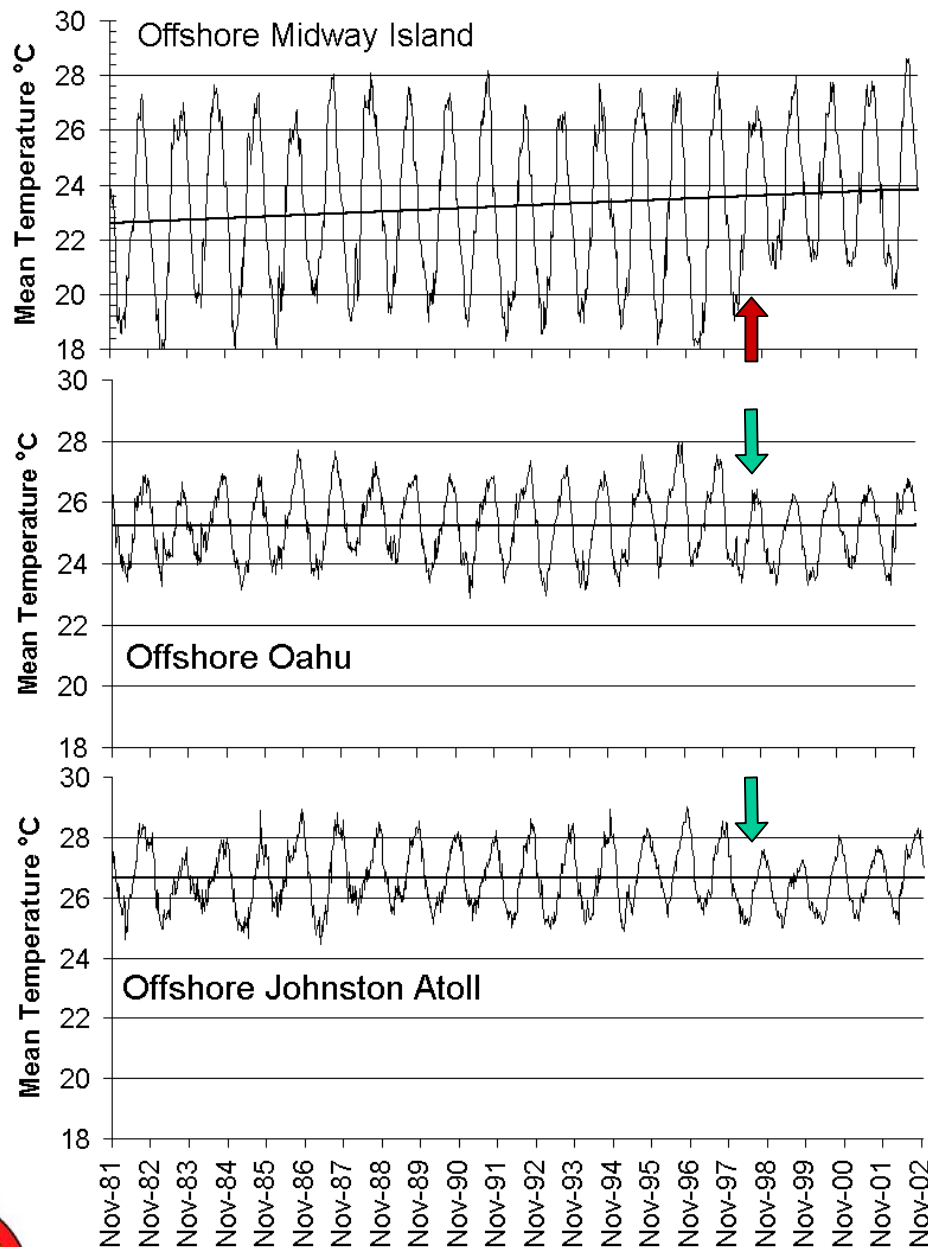


Major factors leading to the 1996 mass bleaching event:

1. Regional offshore positive summer temperature anomaly exceeding $+1\text{ }^{\circ}\text{C}$.
2. High surface irradiance (summer irradiance, low cloud cover).
3. Low wind speed.
4. Restricted water circulation in shallow Kaneohe Bay leads to rapid heating under these conditions.



Source: P. L. Jokiel and E. K. Brown "Coral bleaching in relation to regional temperature trends and patterns". Hawaii Coral Reef Assessment and Monitoring Program (CRAMP)



The 1998 El Niño caused massive bleaching throughout the tropics, but not Hawaii.

But oceanographic changes occurred in the Hawaiian region.

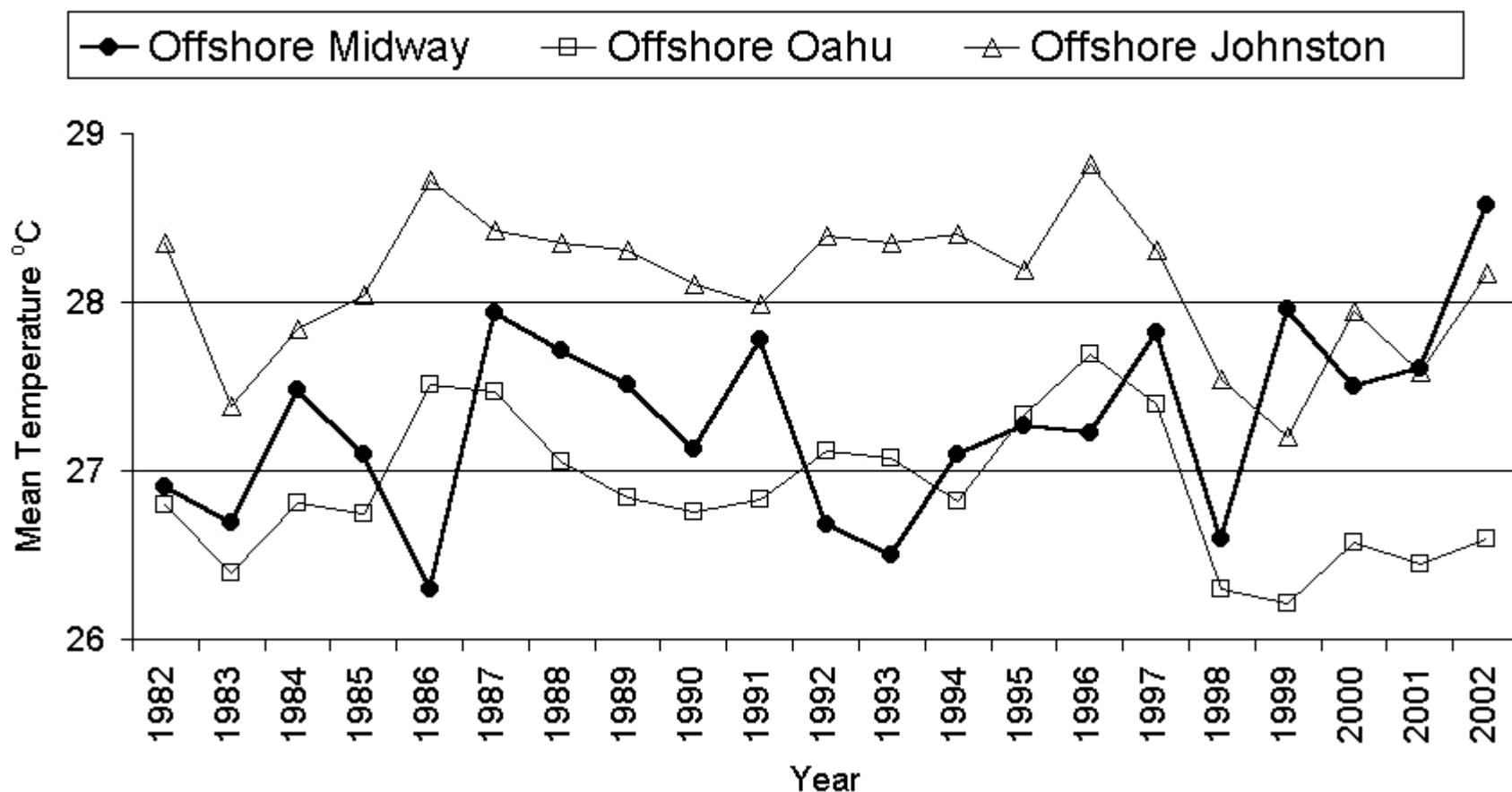
Offshore temperature patterns show a temporary interruption of long-term trends with warming at high latitudes and cooling at lower latitudes.

Thus the 21 year IGOSS-NMC data set for offshore Oahu does not show the significant increasing trend noted for the 43 year Oahu record. The data reveal a strong warming trend ($p > 0.001$) for Midway waters.

Source: P. L. Jokiel and E. K. Brown "Coral bleaching in relation to regional temperature trends and patterns". Hawaii Coral Reef Assessment and Monitoring Program (CRAMP)



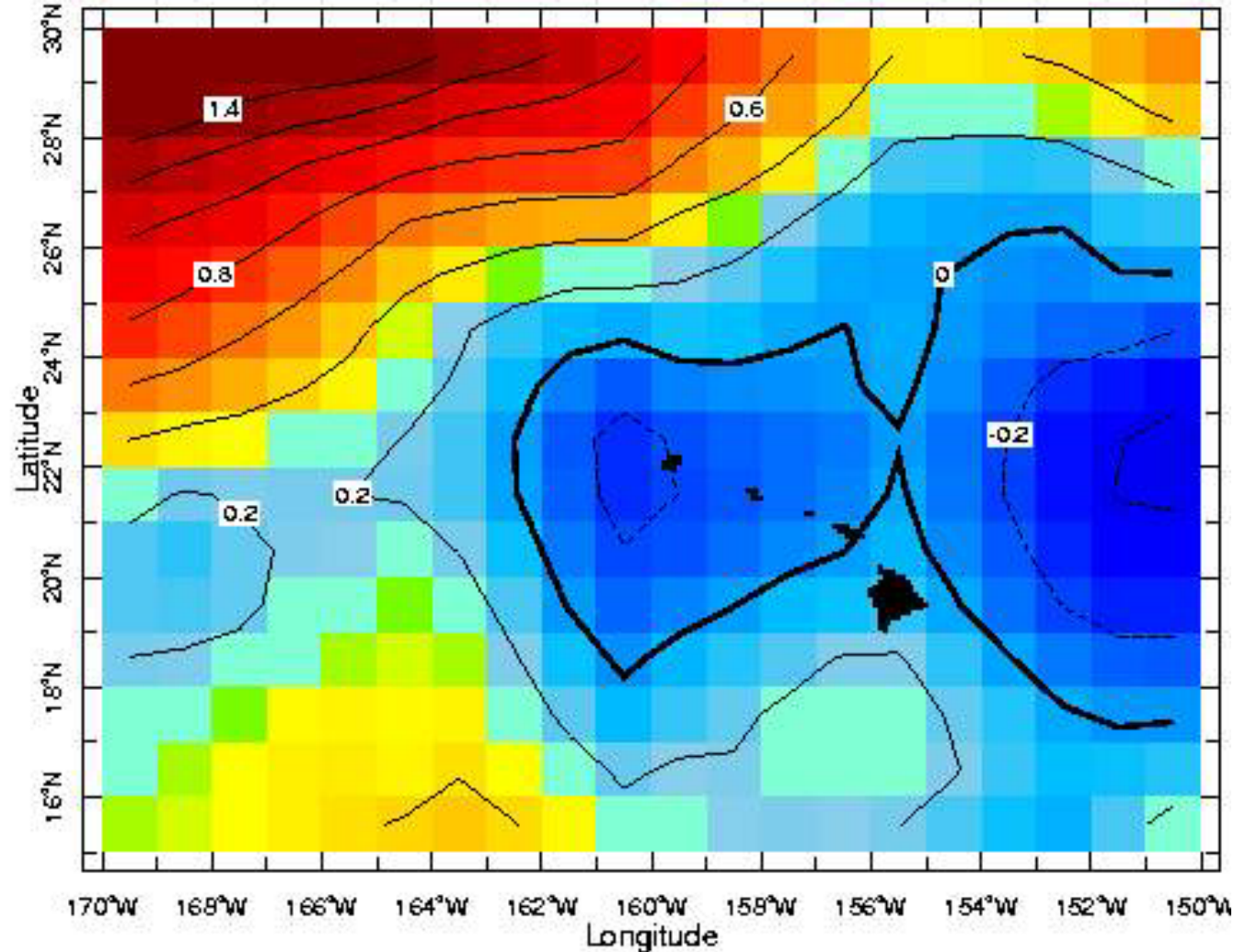
Warmest Four Consecutive Weeks, IGOSS-NMC Data



In recent years Midway Atoll (28.2°N) shows higher prolonged offshore summer temperature than lower latitude areas off Kaneohe Bay (21.5 °N) and Johnston Atoll (16.5 °N).

Source: P. L. Jokiel and E. K. Brown "Coral bleaching in relation to regional temperature trends and patterns". Hawaii Coral Reef Assessment and Monitoring Program (CRAMP)





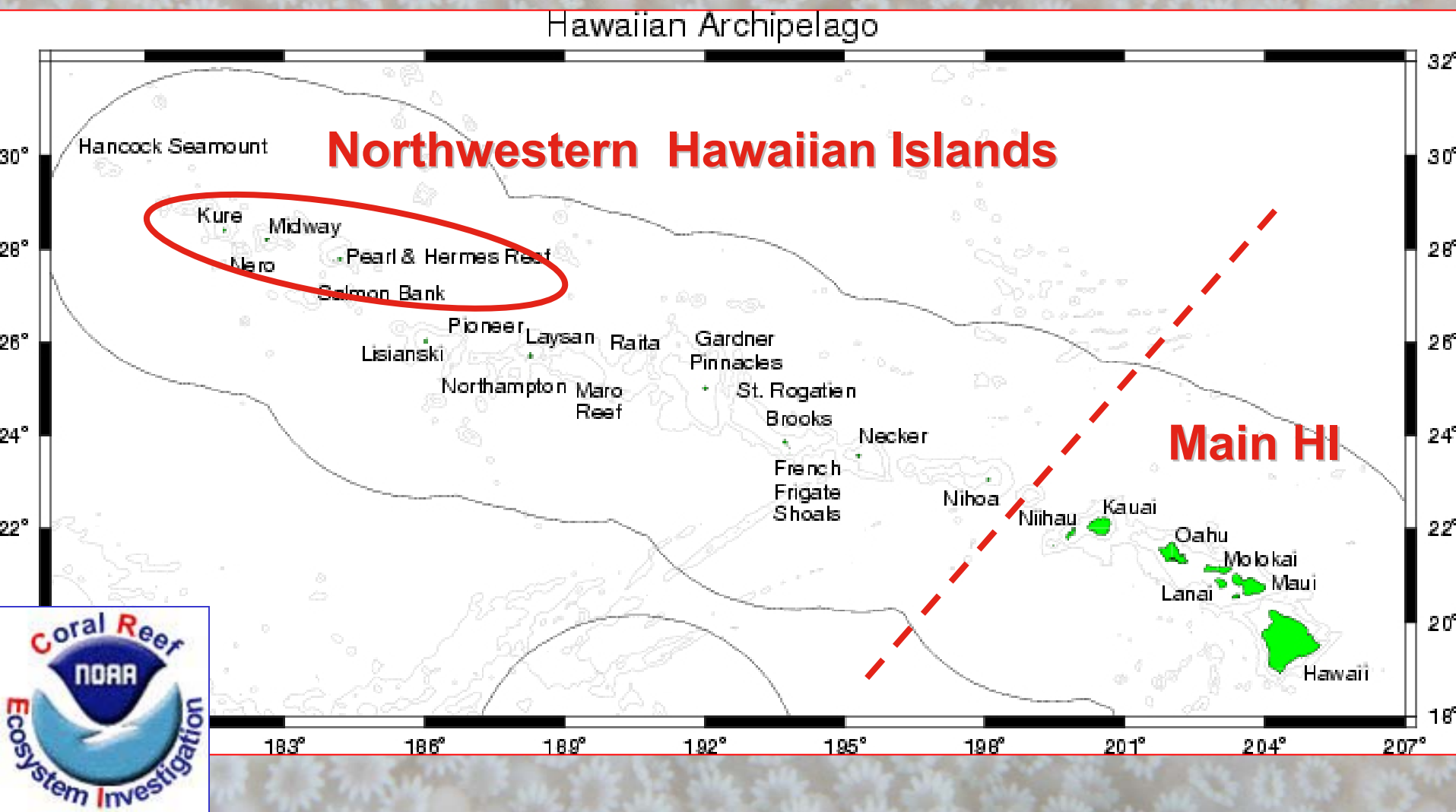
28 Aug 2002 Temperature values are in °C above mean long term summer maximum

The 2002 bleaching event impacted the northern portion of the Archipelago with cooler temperatures in the Main Hawaiian Islands.

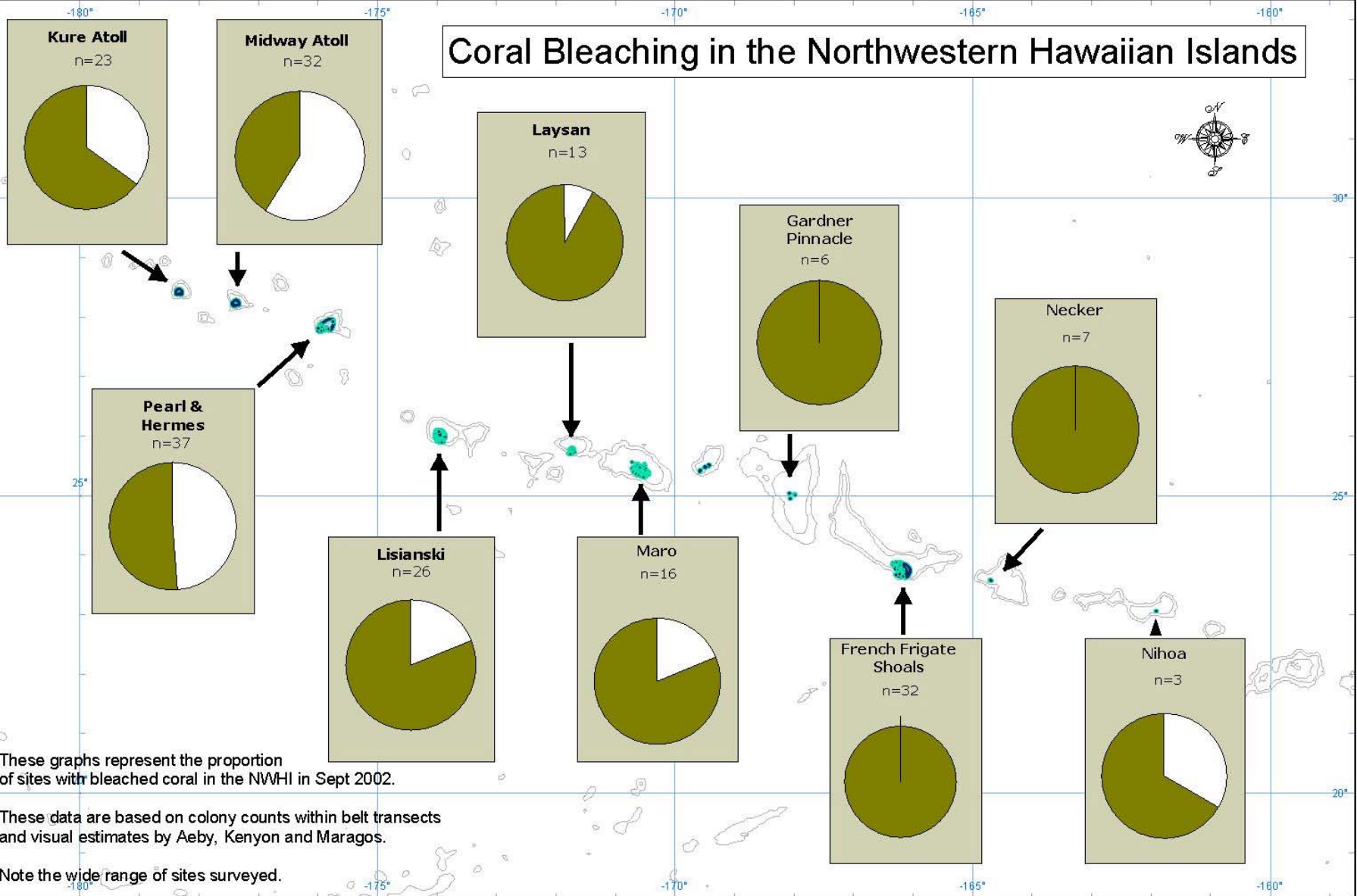
Data Source: Integrated Global Ocean Services Division (IGOSS), US National Meteorological Center (NMC)



Towed Diver Survey Assessment of Coral Bleaching, NWHI, 2002



Coral Bleaching in the Northwestern Hawaiian Islands



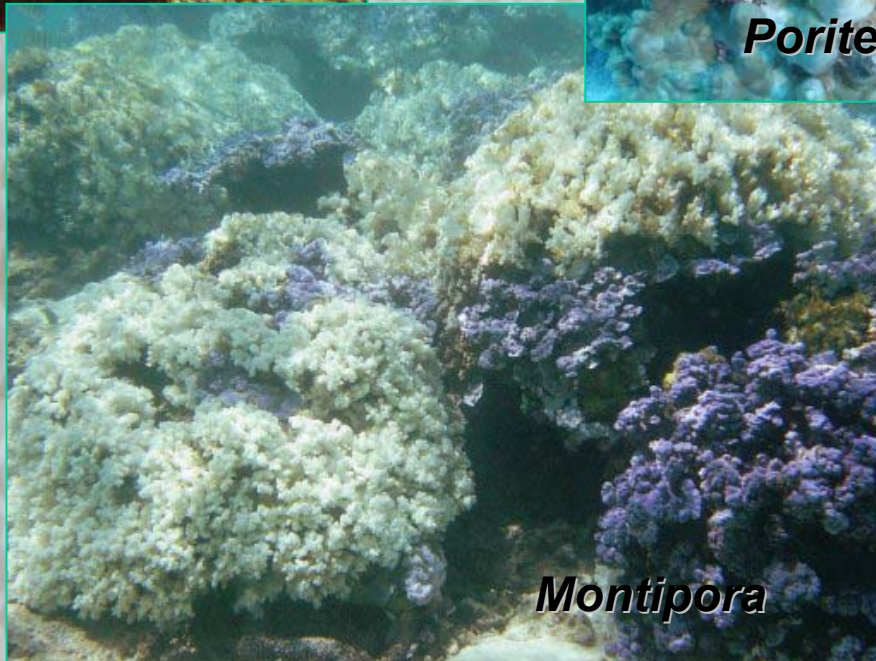
NWHI Coral Bleaching 2002



Pocillopora



Porites



Montipora

Conclusions

- **The trend of increasing temperature in Hawaiian waters is similar to warming trends observed in coral reef areas throughout the world.**
- **Demonstrated predictability of the bleaching phenomena and evaluation of temperature trends in Hawaiian waters leads to the conclusion that such bleaching events will increase in frequency and severity in future decades.**
- **The greatest impact will be in areas of restricted water circulation (bays, lagoons and in mesoscale eddies that form in the lee of Hawaii and Maui).**
- **The northern portion of the Archipelago is more prone to bleaching than lower latitudes.**



Paul L. Jokiel

Hawaii Coral Reef Assessment and Monitoring Program (CRAMP)

Management needs

- ❖ **Monitoring**
- ❖ **System for rapid response by agencies**
- ❖ **Ability to access remote regions**
- ❖ **Recovery ability of different coral species, reef types and regions**
- ❖ **Rate of recovery in impacted vs. pristine areas**
- ❖ **Connectivity among and within island groups**

Management needs

- ❖ **Differential susceptibility of different coral species, reef types and regions**
- ❖ **Regional and local oceanographic processes**
- ❖ **Relationship between bleaching and disease susceptibility**
- ❖ **How other stressors affect a coral's ability to withstand and/or recover from bleaching**

Acknowledgements

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